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Selected Unsuitable Problematic Rocks in Geotechnics

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Abstract

The aim of this publication is to highlight some selected case studies that relate to issues of interaction of the geological environment with engineering construction. This is an issue of flysch sediments, karst areas, liquefied sand, loess sediments and basalt rocks. This geological environment is causing many problems. This can cause problems during the construction process, or in trying to preserve the long life of these constructions. Mentioned problematic rocks can complicate future or existing construction through landslides, low bearing capacity, differential settlement, karstification, filtration faults and many other disorders. Labelling the rock as problematic rock is debatable. Each geological environment is affected by a large amount of geofactors. These geofactors input to deciding about the appropriateness or unsuitability of the foundation soil and their risks. Generally, the unsuitability of the foundation soil is determined by a combination with geofactors such as ground water, earthquakes, sloping terrain and many others. Therefore, it is necessary to designate "problematic rocks" understood as an environment with many problems. That means problems with foundation engineering and existing constructions at a high rate. This designation also includes an environment where the consequences of construction failure have unforeseen consequences. Problematic rocks also include soft rock, which is dedicated to a number of other publications. Although each environment is completely unique, learning from mistakes and lessons learned from other countries is very important.

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Keywords: liquefied sand; karst; flysch; loess; basalt.

1. Main text

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Problematic rocks [fig.1] are rocks that generally have more problems in foundation engineering. In the case of these rocks, engineering geologists must be careful and focus on some specific problems occurring just in the case of these rocks. Problematic rock can be classified as soft rock group and a group of other problematic rocks. The publication focuses on a group of other problematic rocks. Within the other problematic rocks, we can distinguish flysch rocks, which are characterized by a susceptibility to sliding. This also includes liquefied sand. Liquefied sand causes filtration faults, suffosion, problems with a low bearing capacity and different settlement. Furthermore, collapsibility basalt belongs to this group. Collapsibility basalt struggles with problems related to low bearing capacity and different settlement. Collapsibility loess also usually has problems with low bearing capacity and different settlement. Gypsum also tends to have a low bearing capacity, problems with different settlement, dissolution, karstification and subsidence. In the case of limestone, there are similar problems as with gypsum. However, development of these problems is over a considerably longer period of time. The determination of problematic rocks is not easy and we have to approach it with caution. This is a very simplified list of problems. Each of the mentioned problems associated with many other geofactors. These additional geofactors are specific to different geological, hydrogeological, morphological and climatic environments. The chart below to points the most common problems occurring in above mentioned rocks and presents case studies from some countries in the world.

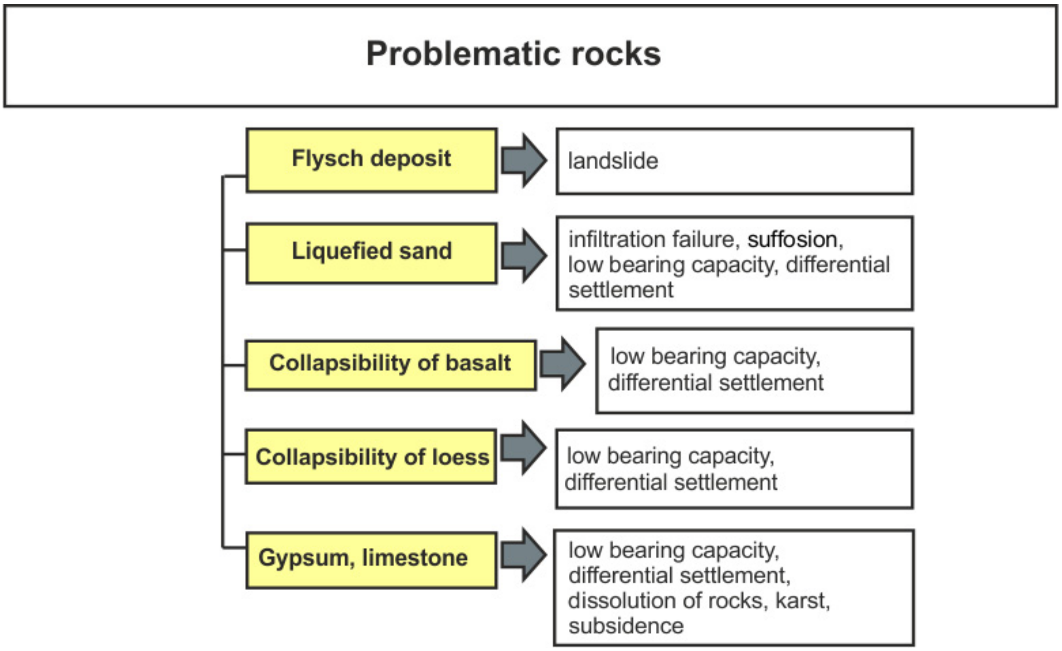

Fig. 1. Scheme – Problematic rocks.

1. Problems associated with the occurrence flysh rocks

Significant representation in the group of problematic rocks in relation to engineering constructions, represent flysch rocks. Flysch rocks can be generally described as complex layers of marine origin. The complex of these layers is formed by rhythmically stratified and alternating clastic sediments, often with a positive gradation layering. These clastic sediments consists mainly of psammites to pelites. Fauna is a rare occurrence. Flysch composition is sometimes similar to sediments of deep deltas. Position flysch in the pan decides on its composition. The proximal flysch is so coarser. The distal flysch, saved away from the source material is very fine-grained. From the perspective of tectonic, sediments deposited during the closing geosyncline for tectonically unstable and seismic conditions, it is considered like flysch.

The issue of flysh rocks when excavating a tunnel was dealt with by the authors Marinos et. al [5]. It is the excavation of tunnels along the Egnatia Highway. This highway is a very important modern route connecting

Greece with Europe. It is a 680 km long section. Highway runs across the whole width of Greece. This highway goes through nearly perpendicular to the main geotectonic units. Weak flysch rock massif crossed by a major tectonic contacts. The tunnel is oriented perpendicular to the axis of the large subsidence anticline and syncline. Places with a predominance of silt, they are also interspersed with thin layers of sandstones. The tunnel through a tectonic shear zone causes a lot of problems. Weak rock units with high heterogeneity, including shear zones are very complicated task for civil engineers and engineering geologists. The classification of rock mass, which formed during the long geological time periods, it is very difficult to classify rocks based on the known classification systems rock mass. Mechanical parameters of rocks are very difficult to detect because the real strength of these rocks cannot be measured in the laboratory. It will be appreciated that the strength of intact rock is reduced during excavation, desiccation, but also in the event of disruption of the surrounding rocks. They can also connect other deformations. Excavation of the tunnels was carried out in an environment with different tectonic evolution. Determination of the geotechnical parameters of rock mass using a common classification is very important. However, the best way is to use the method of back analysis. Back analysis may be performed not earlier than during construction. Rock classification system was performed by the rock mass classification systems, GSI and RMR. It was found that these values are similar to the values set by back analysis. However, the value of uniaxial compressive strength of intact rock was lower than the value considered in the design [5].
The method of back analysis creates the most reliable tool for determining the properties of the rock mass, especially if it is a very weak and shear rock environment.
Many problems are also caused by flysch sediments in the Czech Republic. Their potential was demonstrated in particular during periods of extreme rainfall. The area with the occurrence of flysch sediments is not negligible. This is due to the small area of the territory of the Czech Republic. Therefore, we cannot completely avoid the implementation of engineering facilities in these places. This is particularly the case of the Western Carpathians where landslides occur in a greater or lesser extent in the long term. The slip surface can occur closer to the surface. These shallow landslides do not cause such fatal consequences such as landslides with great depth of slip surfaces. Frequent landslides are supported by substantial morphological segmentation and landscape influenced by man, such as the existence of agricultural land. Damage caused by numerous landslides had an impact not only on local roads, railway lines, but also at local residences. It also endangers people's lives. Utility networks and rivers are also affected. Many places are constantly monitored. Methods of monitoring will vary depending on the sizes of landslide areas. This is a geodetic method to monitor inclinometer measurement in boreholes. This takes place in cooperation with geophysical methods such as georadar or shallow seismic. Measures against landslides and rehabilitation of these areas are very costly. The possibility of complete elimination of risk in these vulnerable areas is very limited.

2. Problems associated with the occurrence of karst areas

If we talk about problematic rocks in relation to engineering constructions, then we must not forget karst areas. Karst is formed in soluble carbonate rocks, which are formed by carbonate minerals like calcium carbonate. Among karst rocks are also the so-called evaporites, formed by evaporation of water from the remaining minerals of the aqueous solutions. Ranking among the evaporites are rock salt, gypsum and anhydrite. Gypsum is formed by precipitation or hydration of anhydrite in near-surface conditions. Gypsum can be present in the subsoil like massive boards or as a vein. It leads to wrinkling and buckling of the gypsum positions due to an increase in volume. Gypsum which arises from anhydrite is permeated by a dense network of fissures. This increases the throughput, and it can lead to the formation of large cave systems. Karst in conditions of gypsum is formed significantly faster than in the case of limestone.
Conditions for the construction of bridges and roads under these circumstances became very difficult. Gypsum karst presents a number of problems, especially with the formation of subsidence. Road construction must deal with the karst phenomena during building and existence, including the possibility of gradual dissolution, formation of sinkholes and the possibility of collapse layers.
The authors Cooper and Saunders [2] have dealt with the construction of a bridge in gypsum karst areas. Gypsum karst presents a number of problems in the Permian and Triassic rocks in England. Geophysical methods, such as resistive tomography were used for the survey of geological conditions at the construction. Their occurrence can be associated with the occurrence of sulphates. Water containing sulphates may have a negative effect on concrete constructions. This fact is also necessary to take into account when building structures under these conditions.

England achieves gypsum thickness sequences in the Permian and Triassic strata. The biggest problems here are the karst rocks of Ripon North Yorkshire. Gypsum karst of the Triassic is located in the Midlands, south west of Derby. Construction of bridges and viaducts in the area of active dissolution of gypsum karst is very difficult. Methods that are used to improve the properties of the subsoil in the limestone karst appear to be inappropriate in case of gypsum karst. In case of limestone karst, this is a filling of cavities with grout or a surface stabilization. Using these methods in case of gypsum karst is possible only provided there is very limited groundwater movement. In areas where there is increased movement of groundwater, there is a rapid dissolution of gypsum and a grout sealing is unsuitable. Firstly, due to the size of the cavity, it becomes problematic to seal of these cavities. Secondly, the aggressive nature of sulphates contained in these waters causes issues. A partial, incomplete grouting may even worsen the situation by causing better conditions for dissolution in the surrounding terrain. Therefore, it is necessary to inject the Karst with special mixture that is resistant to sulphates [2].

Fast development of gypsum karst areas brings with it the need to develop tools for its monitoring. This is important especially in regions with rapidly flowing groundwater. In case of a dense agglomeration of these areas, monitoring should not be neglected. In karst areas, the main concern is about the underground system, which is constantly evolving, and changing its form. Knowledge the development of a gypsum karst and groundwater flow allows a better understanding of the area and to ensure effective measures against damage to buildings and infrastructure, which are usually accompanied by the occurrence of karst. In the case of gypsum subsoil, the focus on careful and continuous monitoring is particularly important.

The survey is carried out using a variety of geophysical methods. One of the most frequently used method is the method of electrical resistivity tomography. It is a highly variable and universal method. Various electrode configurations enable results of different nature. The method is focused on measuring the resistivity of underground via electrodes. The method allows obtaining valuable information on the geological environment. It needs a place saturated with water, fissures, caverns and many others. A focus on developing tools for the better understanding of karst systems and the effective monitoring of these areas is presented in [4]. The publication focuses on describing the hydrogeological situation and the development of methods for detecting the development of Karst area in Switzerland in the southeast of Basel. A gypsum karst landscape is reflected by subsidence of the dam and adjacent highway. In the area monitoring is performed for the protection of underground and surface water. Specific attention was focused on the work of the hydraulic behaviour, whose knowledge is essential in the case of Karst area. The area is filled with a number of monitoring wells with electrical resistance tomography.

Problems also occur in connection with limestone karst. This issue was examined in southern Turkey [7], deals with the infiltration of water in the rock-fill dam through the limestone karst. Grouting failed to prevent water leakage. There were observed fluctuations in groundwater levels, leakage direction and character of karst. Dye-based tracer tests were used. Based on the hydrogeological study it was found that the leakage occurs in the karst limestone between the dams in a spillway.

3. Problems associated with the occurrence of liquefied sands

Another of the many problems that may occur in the interaction with the building structure and can cause incalculable damage, are called liquefied sands. This phenomenon is connected with so called underground suffosion. Any loose soil under certain conditions can get into a state of fluidity. If water leaks through sand, it overcomes the friction in the gaps between the grains. The water pressure is then transferred to the sand grains, causing liquefaction. Soil decreases its volume by shear stress. There is also a reduction of the pore volume and the excess water flows out from the soil. Friction is minimal and the sand becomes, for a certain time, fluid. Another possibility of soil liquefaction is a large porosity of soils with colloidal filler of pores. Under these circumstances, the excess water is squeeze out very slowly. The fluidity of the sand is not the only transitional.

An important criterion is no excavating, cuts or construction pit should go without a thorough engineering geological survey. In areas with problematic foundation soils and low-bearing capacity of soils, constructions are often build on piles long, slim pillars. These pillars are able to transfer loads from the building into a greater depth. Soil liquefaction can have a strong impact to these piles and the pile can be called floating. It means that the heel does not reach bedrock. Pile surface friction cause on a floating pile. A pile may also be called end-bearing pile, when it reaches up to solid subsoil. This type of pile causes pile surface friction and transfers stress to the heel pilots. If there is liquefaction of soils, they are beginning to behave like thick liquid mass and piles may be a breach. Liquefaction sand issues with an impact on pile foundations were studied by Bhattacharya et al. [1]. For the construction, this phenomenon is entirely destructive and in many cases deadly. That is why this phenomenon requires greater attention. In a country with frequent earthquakes, soil liquefaction is caused by another impulse. Different is of course their access to the design and size of the measures against increased failures of these objects. The correct engineering design to the specific environment can significantly help to eliminate possible consequences. The size of disturbances on piles as a result of the earthquake and due to liquefaction sand is very hard to detect. This is due to the great depth of piles set into the subsoil. A possibility is a piles extraction and utilization of drill cameras to explore the consequences of the rock environment. This was done twenty years after the earthquake in Nigata and in Kobe. The piles were severely damaged in exposed points. The issue of liquefied sand in connection with the building structure is still under investigation. Based on the damage to the piles in the liquid sands and damage to structures of historical earthquakes, it is possible to learn and develop ever better designs, according to the latest engineering knowledge [1].

Knowledge areas with the potential threat of liquefaction sands are essential for the appropriate type measures for the construction. This topic is dedicated writers Wang et al. [8]. It was performed extensive testing of properties sands. They were performed laboratory monotonic and cyclic triaxial tests to evaluate static properties, dynamic properties and resistance of sand to liquefaction. In the publication, it was found that the zone of the edges of the dam and in the vicinity of the upper stream of the diaphragm wall is more susceptible to liquefaction, than in free field. According to these results it is possible to considerably effectively design precautions. As the least prone to liquefaction zone is beneath the centre of the dam [8].

4. Problems associated with the occurrence of basaltic rocks and loess sediments

Basaltic rocks and loess sediments are among the problematic rocks, causing especially problems with low bearing capacity and different settlement.

Basaltic rocks are the most common extrusive igneous rocks. Characteristic is a fine-grained structure, which is determined by the rapid solidification at the surface of the earth. Basalts often cover a large area and occur as columnar formations, surface currents, underwater creates so-called pillows. Often, they include admixtures of volcanic glass. The composition of basalts varies depending on their genesis. Basalts are divided into group's tholeiitic that cover large areas of the earth's surface. Furthermore, they are divided into a group of alkaline basalts, which occur especially in the form of volcanoes.

Loess sediments are caused by eolian activities in areas without vegetation cover near glaciers. Loess composition is determined by the type of weathering, from which it is created. Commonly, they are composed especially of quartz, feldspar, mica and others. Loess also contains calcium carbonate. Loess sediments are particularly suitable for agricultural activities, for their good fertile characteristics.

Loess and basalt foundation soil occur in the Czech Republic. Basaltic foundation soil is found in České Středohoří. This is a smaller complex of volcanic bodies. In this area, tunnels were realized through weathered basalt rock, [6].

The process was complicated by the fact that it is a protected natural area. It is also an area significantly morphologically variable, geologically complicated with the occurrence of a landslide. Due to the high terrain segmentation, it was necessary to focus increased attention to surrounding slopes and cuts. In the past, blasts were realized in nearby quarries. Violation of the rock mass caused by these blasts lead to complications during the construction of the tunnel Prackovice.

The issue of loess sediments is described in the publication from Derbyshire [3]. The publication covers extensive loess regions in northern China. Loess collapse of structures has destructive, sometimes deadly effects on infrastructure. Frequent monsoon rains and earthquakes combined with loess soils represent great risks to wide urban agglomerations.

5. Conclusion

Problematic rocks negatively affecting engineering constructions. Cases occurring of problematic rocks are a worldwide. Flysch sediments are about the presentation on a case study of tunnel excavation. Geological and tectonic conditions in this area represented a high risk on the one hand in terms of security and from the perspective damage to underground structures.

Another case mentioned in connection with flysch sediments was in the Czech Republic. Problems occurred

especially during periods of extreme rainfall. This is particularly the case in the Western Carpathians, where landslides reflected a greater or lesser extent, in the long term.
Karst areas describe issue of construction of bridges and viaducts. This case is not extraordinary in the world. In contrast to limestone karst, gypsum karst cavities are created much faster. Additionally they contain a very aggressive environment. These are the reasons why we need approaches to this environment entirely specifically.
Another case, which is presented in the publication, is the issue of sand liquefaction. Building construction in areas susceptible to liquefaction sands, it must be specially designed to withstand its effects. Liquefaction sands may be caused by several factors. In this case is effect of earthquakes. Liquefied sands behave very dangerous. There is a loss of strength the rock environment and sand moves like a thick liquid mass. This phenomenon can be especially in urban agglomerations very destructive effects associated with loss of life.
Characterized was also the issue of basaltic rocks and loess. Basaltic rocks represent a dangerous foundation soil during the excavation of a tunnel in the Czech Republic. Loess rocks form an extensive problem in the regions of northern China.
Publications created a simple overview of problematic of rocks and their most common problems in the interaction with the engineering construction.

References

1. Bhattacharya, S., Dash, S. R., Adhikari, S. (2008). On the mechanics of failure of pile-supported structures in liquefiable deposits during earthquakes. Current Science-Bangalore, 94(5), 605.
2. Cooper, A. H., Saunders, J. M. (2002). Road and bridge construction across gypsum karst in England. Engineering Geology, 65(2), 217-223.
3. Derbyshire, E. (2001). Geological hazards in loess terrain, with particular reference to the loess regions of China. Earth-Science Reviews, 54(1), 231-260.
4. Epting, J., Huggenberger, P., Glur, L. (2009). Integrated investigations of karst phenomena in urban environments. Engineering geology, 109(3), 273-289.
5. Marinos, V.: Fortsakis, P., Prountzopoulos, G. (2006). Estimation of rock mass properties of heavily sheared flysch using data from tunnelling construction. IAEG2006, paper, (314).
6. Svoboda, J., Novosad K. 4/2008. Tunel: Tunnels across the České Středohoří highland. vol. 17. 65-69.
7. Turkmen, S., Özgüler, E., Taga, H., Karaogullarindan, T. (2002). Seepage problems in the karstic limestone foundation of the Kalecik Dam (south Turkey). Engineering geology, 63(3), 247-257.
8. Wang, G., Wei, X., & Liu, H. (2015). Liquefaction evaluation of dam foundation soils considering overlying structure. Journal of Rock Mechanics and Geotechnical Engineering, 7(2), 226-232.